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ALLEGED CONTAMINATION OF PRIVATE WELL WATER SUPPLY BY CHEESE & WHEY WASTE WATERS

township of portland
community of harrowsmith

Ministry of the Environment

Ontario

MINISTRY OF THE ENVIRONMENT

TOWNSHIP OF PORTLAND - COMMUNITY OF HARROWSMITH

ALLEGED CONTAMINATION OF PRIVATE WELL WATER SUPPLY

BY CHEESE & WHEY WASTE WATERS

INTRODUCTION

In response to a request from Mr. G. Massey, Industrial Wastes Branch, an investigation was conducted by the Water Quantity Management Branch to determine the cause of the contamination of private well water supplies near the Community of Harrowsmith.

This study has included an office examination of water-well records on file for the area and a review of pertinent literature. Field work has consisted of an examination of geologic and topographic features, the collection of well-water samples for chemical analyses and interviews with local residents. A long-term water quality sampling program was undertaken to establish, if possible, a cause and effect relationship. Well locations and sampling locations are shown in Figure 1.

BACKGROUND

Mr. M. Redden, the complainant, reported that his well, which was drilled in 1964, had yielded good quality water up until early July, 1972. At that time an odour and taste was recognized in the water which progressively became worse with time. No improvement in the water quality had been experienced by the Reddens at the time of the initial field survey on August 4, 1972. The water could not be used for any purpose because of

its highly offensive odour. The water also contained what appeared to be a large amount of suspended decaying organic material. The Redden well location is shown in Figure 1.

The Reddens felt that the spraying of whey-waste water on the field shown in Figure 1 had affected their well-water quality as they noticed the change approximately 1 month after the commencement of the spraying of waste water on the field. Other residents in the area expressed concern for the future quality of their well waters. Mr. Peters, whose well is located in Figure 1, considered that his well-water quality had already been affected by the spraying of the whey waste.

The spray irrigation area occupies 35 acres of open, cultivated fields and is located about 2000 feet north-east of the complainant's well. The spray site is on a local high point of land and is elevated approximately 50 feet above the Redden well. A whey-waste storage lagoon is located about 1200 feet south-west of the Redden well. The waste is pumped via a pipeline from the lagoon to the fields for spray irrigation. The lagoon is directly underlain by fractured bedrock and is elevated approximately 15 feet above the Redden well.

During the field investigation, a break in the pipeline from the lagoon and factory to the spray field was found adjacent to the swamp. The location of the break is shown in Figure 1. Whey-waste water had seeped from the break into the swamp. The break in the pipe was corrected in the latter part of September, 1972.

GEOLOGY

The overburden in the Harrowsmith area is generally less than 10 feet in thickness and consists mainly of a stony, clayey till. The underlying bedrock, consisting of limestones and shales of the Trenton-Black River group, is jointed and fractured as seen in several local outcroppings.

The overburden at the spray disposal site is 1 foot in depth on the average. The soil material is a loam developed on calcareous stony loam till. Pieces of the underlying bedrock have been brought to the soil surface through cultivation of the sprayed field. The bedrock also outcrops at various locations in the field.

HYDROGEOLOGY

In the study area, domestic water supplies are obtained from wells drilled into the bedrock. In general, the wells are 50 to 60 feet in depth depending upon the depth to the water-bearing fractures, joints or bedding planes from which the water is obtained.

A precise levelling survey was completed in the area to determine the direction of ground-water movement. On a regional scale, ground water moves in a west to southwest direction, from the spray area toward the wells. Discharge of the sprayed waste takes place at an elevation of about 550 feet above

mean sea level, or roughly 40 feet above the lagoon level and 55 feet above the water level in the swamp shown in Figure 1.

Effluent sprayed on the field is expected to infiltrate through the shallow soil to enter the underlying bedrock and become part of the regional ground-water flow system. Similarly, it is anticipated that the waste water that leaks from the lagoon which is directly underlain by rock, will also become part of the regional flow system. A certain portion of the waste water from the lagoon may enter a local shallow flow system and discharge to the swamp.

The local ground-water flow pattern is likely different than the regional pattern. The study area is located in a fairly broad depression in which there is limited surface drainage. As precipitation in Southern Ontario exceeds evaporation, the main water discharge in the area likely takes place via the subsurface. This also suggests that the sediments and the rock in the area are relatively permeable.

The levelling survey established that the water level in the swamp was 6.6 feet above the static level in the Redden well. In addition, local rock outcropping shows that wide, well-developed fractures and joints are oriented from the swamp toward the Redden well. Therefore, it is likely that the swamp feeds the aquifer tapped by the Reddens.

WATER QUALITY

Water obtained from the bedrock in the study area is generally fresh with a low to moderate chloride content. It may have a mild hydrogen sulphide odour. Samples of well, stream, spring, swamp and lagoon waters in the area were collected on many occasions, and the analyses results are presented in Table 1. The locations of the sampled wells are shown in Figure 1. The Mitchell well, which is remote from the immediate study area, will serve as a reference to background water quality.

It should be noted that lactic acid was found to be present in a number of well waters during the study; however the analytical method (Barker-Summerson modified by J.D. Pryce, Analyst, 1969, Vol.94, 1151-2) used by the Ministry laboratory personnel was developed only for semi-quantitative determination. Because lactic acid was found in every well sampled on November 28, 1972, except the Peters well and in none of the waters sampled on August 15, 1972, including the whey waste lagoon water, the validity of the lactic acid tests is doubtful. For this reason these results will not be considered in the interpretation of the water quality problem.

Residents suspect that whey-waste water sprayed on the disposal area has contaminated their well-water supplies. The whey-waste water, as sampled in the lagoons, contains high concentrations of organic material as shown by the BOD, TOC and Kjeldahl nitrogen content. The water also contains a high concentration of dissolved solids including chloride, sulphate, calcium, potassium, phosphorus and free ammonia. The waste

also has very high concentrations of enterococcus bacteria but no fecal coliforms and low concentrations of coliform bacteria.

If this waste water, after spraying on the irrigations fields, is entering local water supplies after considerable travel time through a fractured limestone aquifer, the resultant water supply would be expected to be a mixture of background waters and waste waters. However, it is apparent from a study of the water analysis data that the Redden and Peters wells were contaminated with poor quality water in the summer and early fall of 1972, but that these wells are now yielding water that is similar to background water quality.

The chemical analyses data of Table 1 has in part been presented in a series of graphs, Figures 2 to 8, to permit a better understanding of the changes of water quality with time. From these figures it can be seen that the Redden and Peters well waters and the swamp water had dramatic decreases in mineral content from October to November, 1972. This is particularly evident in Figure 8 - the graph of conductivity vs. time. Through the winter of 1972-73 to the present, the swamp water and affected well waters have remained similar in quality to background water qualities despite continued spraying in the fields. An examination of the chemical data for samples collected in October, 1972, shows that the constituents in the polluted wells were similar to those in the whey waste polluted swamp (pipeline break) and the lagoons.

SUMMARY AND CONCLUSIONS

For eight years prior to July, 1972 the Redden well yielded water of good quality according to the well owner. However, within approximately 1 month of the commencement of spray irrigation of whey waste water on an approved site 2000 feet upgradient from the Redden well, the water from the well reportedly became offensive in odour and taste. Upon analysis, the water was found to contain unusually high concentrations of organic materials. The BOD, TOC and Kjeldahl nitrogen concentrations indicated that an organic contaminant had been introduced into the water supply. The well water also contained relatively elevated concentrations of chloride, calcium, potassium, phosphorus and free ammonia but normal concentrations of sulphate, potassium and sodium. The chemical composition of the water from the Redden well was very similar to that in the swamp and in the lagoon. It should be noted that nitrite concentrations in the Redden well water were at times higher than the nitrate concentrations. This generally indicates the presence of a very local source of contamination which does not permit sufficient travel time for the rapid change of nitrite to nitrate. Finally, the Redden well was contaminated by fecal coliforms, enterococcus and coliform bacteria.

Geologically, the area is one of thin stony loam till on fractured limestone bedrock. Hydrogeologically, effluent sprayed at the approved site would be expected to saturate the thin soil cover and infiltrate into the underlying bedrock. It would then

be expected to move in a southwestward direction from the spray area toward the affected wells.

The Everton well, located between the spray field and the affected wells, remained unchanged in water quality throughout the study period, as did the Johnston well adjacent to the Redden well. Other wells in the study area were unchanged in water quality during the investigation by this branch. Only the Redden and Peters well waters and the swamp water were unique in water quality during the first 3 months of this study. These waters returned to background quality in the fall of 1972 and have remained at background values even though spraying of waste waters was reinitiated at the spray site in the spring of 1973.

It must therefore be concluded that spraying of whey wastes on the approved site under properly supervised conditions has not and probably will not affect the quality of local well waters.

Whey water was seen to be discharging from the pipe line to the swamp adjacent to the Redden property. The swamp is hydraulically upgradient from the Redden well and at approximately the same grade as the Peters well. Hydrogeologic conditions in the area are such that water in the swamp likely feeds the aquifer. When the break in the pipe was corrected a dramatic decrease in contaminant concentration in the Redden and Peters wells and in the swamp was recorded. Therefore, it is concluded that a loss of waste water from the pipeline break in the swamp in the vicinity

of the Redden and Peters wells temporarily impaired the water quality. With time and natural dilution, the ground-water quality has returned to background quality. Any taste and odour problems present in either the Redden or Peters well water may be attributed to the presence of decomposing organic material in the water because of the poor sanitary construction of both the wells.

RECOMMENDATIONS

1. Neither the Peters nor Redden wells would be expected to yield good quality water because of their poor sanitary construction. Appended to this report are well construction guidelines. Upgrading the construction of these wells would be adviseable.

2. The Harrowsmith Cheese Factory should periodically check and maintain their waste transmission line to ensure that additional problems of this type do not develop.

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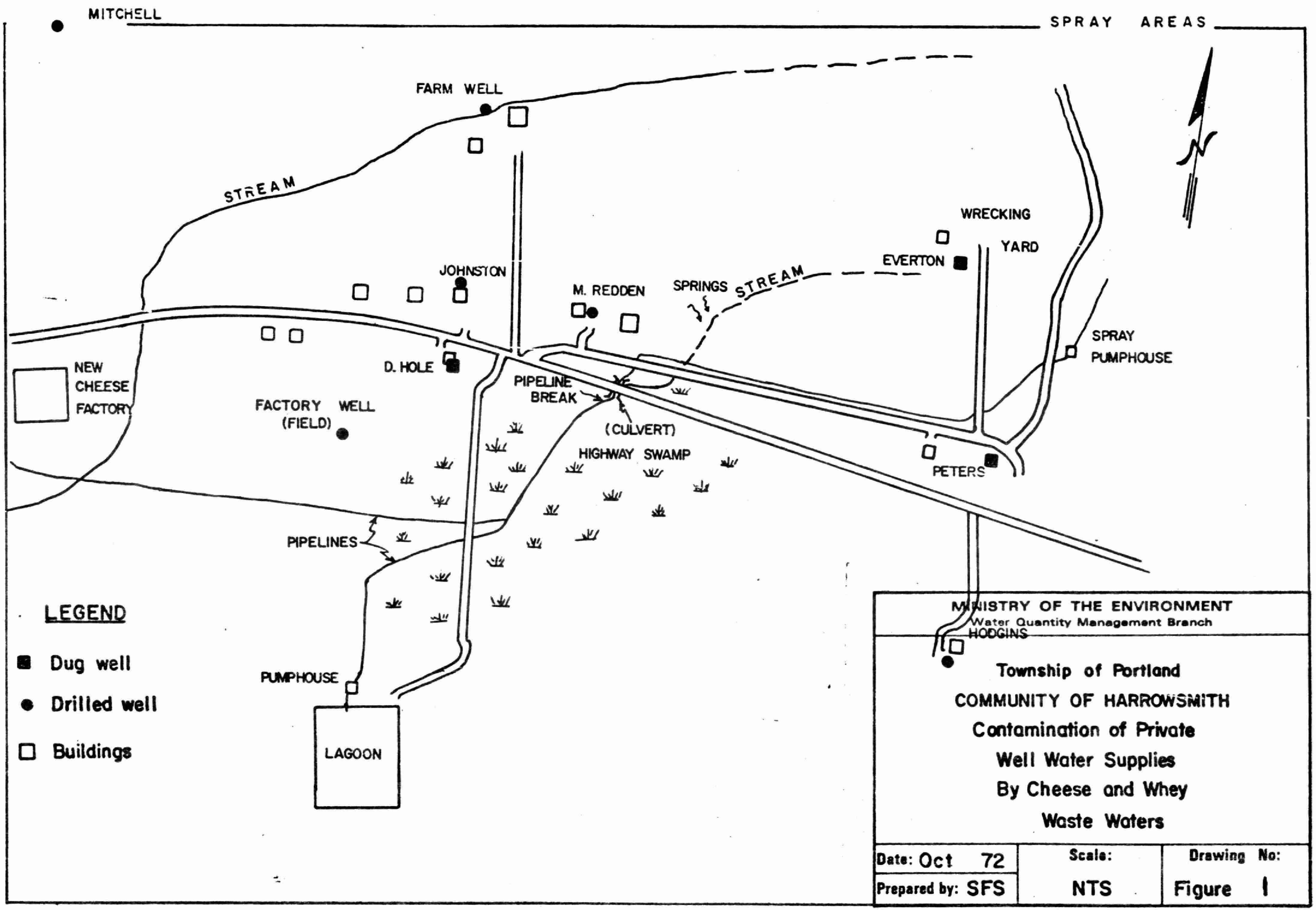


MINISTRY OF THE ENVIRONMENT
Water Quantity Management Branch

Township of Portland
COMMUNITY OF HARROWSMITH
Contamination of Private
Well Water Supplies
By Cheese and Whey
Waste Waters

Date: Oct 72	Scale:	Drawing No:
Prepared by: SFS	NTS	Figure 1

Table 1 Summary of Water Analyses

Prepared by SS

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen NH_4	Nitrogen NO_3	Nitrogen NO_2	Nitrogen Kjeld	Phosphorous (P)	Remarks
										Chemical Constituents in parts per million (ppm)												
REDDEN		4/8/72		3000	1390	3101				165	13	6.60						0.01	0.016	40	0.4	
		15/8/72	NEG	1800	20	2910				120		68.0	532	109	61	8.9	0.95	<.01	0.16	40		oily residue similar to paraffinic lubricating oil
		10/10/72		2600		2241		1320	1083	142	N	23	376	92	44	23	30	<.01	0.1	20	8.4	TOTAL CARBON = 925 ppm N-interference
		12/10/72 23/10/72	40-50 20-30			2543		1540	1130	146	5	30	436	109	46	81	1.6	0.06	0.04	4.0		
		28/11/72	2			825		464	394	36	33	3.0	128	35	18	6.8	<0.01	<0.01	0.008	1.4		
		6/3/73		8.0		710		312	260	48	35	1.2	92	19	28	6.5	0.94	4.3	0.048	1.7	0.076	.063
		4/4/73		1.2	20 COD			326	301	18		1.30		~~.063~~			.18	.68	.037	.58	.024	Man 0.69 H2S 0 MBAS <.1 TOC 16
		11/4/73		3.5	<30	650		328	292	18	40	2.0	94	22	15	3.8	.14	1.5	.026	.43	.031	
		27/4/73		1.2	20	640		326	301	16	31	1.3	94	22	15	5.3	.18	.68	.031	.58	.024	
		8/5/73		9.0		660		252	316	17	33	18.0	99	13	10	8.6	.19	.31	.014	.55	.030	
		22/5/73		2.5	10	685		336	297	17	43	2.1	98	22	17	4.8	.03	.70	.056	.66	.12	Mn 0.56
		5/7/73		46	18	1030		568	536	47	7	12.0	146	50	14	5.2	.01	.02	.003	.20		
		26/7/73				1080		576	555	47		16.0	163	40	16	5.7	0.5	<.1	<.01			

Table 1 Summary of Water Analyses

Prepared by [illegible]

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chemical Constituents in parts per million (ppm): Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen: NH_4	NO_3	NO_2	Kjeld	Phosphorous (P)	Remarks
HOLE.		15/6/72	Neg	0 6	7	1640			310	269	81	0.20	228	27	69	2.3	0.01	11.0	0.010	0.38		
		10/10/72	Neg	1.2	13	1912		730	291	271	119	0.15	248	27	58	2.1	0.2	23.0	0.004	0.37	0.098	
		23/10/72	Neg			2058		832	306	457	79	0.15	260	43	91	2.7	<0.01	3.9	0.007	0.27		
		29/11/72	7			1500		748	285	238	142	0.15	252	29	55	0.7	0.01	27	0.002	0.52		
		5/7/73		80	240	1220		648	742	83	4	29.	166	56	21	7.3	2.8	<.1	.01	32.		
		26/7/73				680		364	353	24		22	90	34	13	2.7	6.1	<.1	<.01			

Table 1 Summary of Water Analyses

Prepared by

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen NH_4	Nitrogen NO_3	Nitrogen NO_2	Nitrogen Kjeld	Phosphorous (P)	Remarks
PETERS		4/8/72		1.2	656	1560				157	173	5.9					0.17	0.77	0.043	1.0	0.2	
		15/8/72	NEG	0.8	2	1530			597	155	39	0.3	204	39	78	2.1	0.13	0.48	0.014	0.62		
		10/10/72		3.5	460	1930		820	712	237	37	11	232	59	162	20	0.45	1.5	0.036	3.5	0.15	
		12/10/72	NEG																			
		23/10/72	NEG			2178		960	754	264	46	0.15	269	69	97	2.6	0.33	1.3	0.014	0.80		
		28/11/72	0			640		340	284	44	30	0.05	106	19	28	1.7	<0.01	0.33	0.002	0.34		
		6/3/73		6.0		483		212	226	13	20	0.40	62	14	28	4.3	0.02	0.43	0.014	0.99	0.22	
		11/4/73		4.0	COD <30	570		268	294	10	22	.1	83	15	27	2.3	<.01	.21	.006	.33	.026	
		8/5/73		0.6	COD <30	730		310	368	12	26	0.15	94	18	49	1.1	<.01	.26	.004	.28	.019	
		22/5/73		0.6	9	700		308	358	11	38	<.05	93	18	45	1.4	.01	.19	.003	1.1	.15	Mn <0.04
		5/7/73		3.5	13	1020		428	534	21	33	.35	126	27	71	1.2	.33	.32	.016	.65		
		26/7/73				1070		448	68	21		11.0	126	32	83	2.6	1.2	<.01	.02			

Table / Summary of Water Analyses

Prepared by SS

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chemical Constituents in parts per million (ppm): Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen: NH_4	NO_3	NO_2	Kjeld	Phosphorous (P)	Remarks
HODGINS		10/10/72		2.0	7	919		128	334	84	43	<0.05	30	13	171	7.1	0.06	0.36	0.004	0.24	0.009	
		23/10/72	1-5			951		144	331	81	43	<0.05	34	14	155	8.0	0.05	0.35	0.003	0.27		
		28/11/72	5			1120		396	391	103	58	<0.05	101	35	115	8.4	0.01	11.0	0.003	0.35		
		6/3/73		0.8		995		184	290	120	44	<0.05	42	19	152	7.4	0.01	1.0	0.002	0.14	0.012	
		8/5/73		1.4	COD <30	1100		252	293	145	55	<0.05	58	26	140	7.8	.01	1.9	.003	.20	.017	
		22/5/73		0.6	9	1020		180	286	125	52	<.05	42	18	149	7.3	.01	1.1	.002	.14	.011	Mn <0.04
		5/7/73		1.6	18	950		136	285	110	50	<.05	30	15	151	7.2	.01	.35	.002	.10		
		26/7/73				980		104	280	111		<.05	27	9	150	7.3	0.1	.2	<.01			

Table 1 Summary of Water Analyses

Prepared by GB

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chemical Constituents in parts per million (ppm): Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen: NH_4	NO_3	NO_2	Kjeld	Phosphorous (P)	Remarks
JOHNSTON		15/8/72	NEG	0.4	4	519			240	12	28	0.45	60	16	26	5.9	0.37	<0.01	0.006	0.50		
		10/10/72		2.0	8	558		226	252	11	33	0.20	53	23	27.	6.1	0.40	0.10	0.002	0.52	0.002	
		23/10/72	NEG			528		222	246	10	31	0.15	54	21		6.6	0.40	0.02	.001	0.42		
		28/11/72	2.			490		228	251	9	33	0.10	51	24	26	6.7	0.40	0.02	0.001	0.58		
		6/3/73		1.6		530		228	250	11	29	2.0	53	23	29	6.5	0.35	0.01	0.002	0.48	0.006	
		4/4/73		0.8	15 COD			218	245	11		0.8		~~.02~~			.34	.01	.001	.53	TOT. SOL .006 .002	Mn .02
		11/4/73		12	<30	530		224	248	14	30	.1	51	23	29	6.7	.36	0.01	0.002	.51	.005	
		27/4/73		0.8	15	520		218	245	11	30	0.80	51	22	32	7.7	.34	.01	.001	.53	TOT. SOL .006 .002	Mn 0.02
		8/5/73		3.5	COD <30	570		242	261	12	33	<0.05	54	26	33	7.2	.18	.02	.003	.30	.013	
		22/5/73		0.4	6	480		264	242	11	30	0.55	99	4	32	7.2	.01	.35	.001	.13	.016	Mn 0.22
		~~26~~ 5/7/73				610			293	18	21	.40	62	29	26	6.3						
		24/7/73				620		260	290	21		<.05	63	49	27	7.5	0.4	<.1	<.01			

Table / Summary of Water Analyses

Prepared by GS

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen NH_4	Nitrogen NO_3	Nitrogen NO_2	Nitrogen Kjeld	Phosphorous (P)	Remarks
MITCHELL		15/8/72		0.8	13	735			286	55	30	0.35	74	21	30	4.8	0.14	0.83	0.012	0.25	0.014	
		10/10/72		1	9	730		236	287	102	40	0.65	55	24	97	11	0.43	0.19	0.031	0.54	0.014	
		23/10/72	PCS			779		304	284	59	44	0.2	77	27	50	6.8	0.25	0.74	0.16	0.38		
		28/11/72	7			725		404	317	54	37	2.4	115	28	12	1.9	0.09	14	0.014	0.27		
		6/3/73			0.4	670		318	290	34	31	0.30	91	22	23	3.1	0.06	1.0	0.002	0.17	0.002	
		11/4/73		1.2	COD <30	570		308	269	15	25	0.30	90	20	5	1.0	0.01	1.5	0.002	.24		
		8/5/73		0.8	COD <30	600		336	283	15	24	0.25	96	12	5	1.0	.01	1.6	.003	.22	.008	
		22/5/73		0.4	6	680		348	288	37	29	0.15	101	23	12	1.5	.03	.90	.001	.20	.026	Mn <0.04
		5/7/73				1240			208	208	40	.25	58	21	156	10	.24 ~~24~~	.11	.013	.33		
		26/7/73				1380		200	296	251		.2	48	19	190	13	0.4	0.2	.02			

Table 1 Summary of Water Analyses

Prepared by SS

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chemical Constituents in parts per million (ppm): Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen: NH_4	NO_3	NO_2	Kjeld	Phosphorous (P)	Remarks
	Redden SPRINGS	MAY 8 1973		160	COD 345	1340		704	613	88	7	27	197	26	28	4.8	.76	.04	.004	4.8	.65	
		MAY 22 1973		400	110	1320		696	602	75	5	330	197	50	30	6.0	1.3	.07	.049	5.8	.78	Mn 9.0

Table 1 Summary of Water Analyses

Prepared by SB

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chemical Constituents in parts per million (ppm): Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Nitrogen: NH_4	NO_3	NO_2	Kjeld	Phosphorous (P)	Remarks
LAGOON	CHEESE FACTORY	16/8/72	NEG	15000	5850 *	7400			1500	841	137	57					185	<0.1	0.03	700	~~450~~	* TOTAL CARBON
		10/10/72		6000	960 *	5013		810	1550	455	N	12	212	68	200	269	310	0.4	0.1	460	32	N- INTERFERENCE
		6/3/73		14,000		6400		2450	0	780	162	38	752	139	365	490	160	<0.1	0.04	570	190	
		11/4/73		9000	COD 12,250	3700		1260	0	409	122	230	392	68	226	314	44.	0.1	0.10	380	150	
		2/5/73		15,000	3772	4350		1140	0	446	144	21.0	360	59	262	384	11.	36.	.1	430	170.	Mn. 1.2
		5/7/73		19,000		10,200		528	3866	551	39	49.0	83	78	320	513	1100.	<.1	.20	1200.		
		26/7/73				9000		1480	4140	700		71.0	440	91	450	570						

Table 1 Summary of Water Analyses

Prepared by SS.

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen NH_4	Nitrogen NO_3	Nitrogen NO_2	Nitrogen Kjeld	Phosphorous (P)	Remarks
FACTORY WELL	FIELD	10/10/72		1.8		1823		66.	312	229	350	0.30	172	43	177	59	0.28	0.30	0.038	0.58	0.05	
		23/10/72	Neg			737		340	353	55	51	0.45	85	31	68	6.3	0.10	0.02	0.004	0.53		
		28/11/72	2			825		332	336	61	66	0.25	80	32	69	6.3	<0.01	0.01	0.004	0.54		
		6/3/73		1.0		1890		620	216	239	475	0.15	190		191	5.2	.25	.89	.010	.44	.029	
		8/5/73		1.0	COD <30	1640		540	249	195	340	0.70	156	36	145	5.7	.25	.28	.021	.49	.03	
		22/5/73		1.4	5	1700		560	246	204	400	0.01	163	37	166	5.7	.28	.32	.007	.47	.024	Mn <0.04

MINISTRY OF THE ENVIRONMENT

Table 1 Summary of Water Analyses

Prepared by SG

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen NH_4	Nitrogen NO_3	Nitrogen NO_2	Nitrogen Kjeld	Phosphorous (P)	Remarks
										Chemical Constituents in parts per million (ppm)												
EVERTON		15/8/72	neg	0.8	10	621			298	5	33	0.25	105	14	7	7.2	0.01	0.33	0.010	0.69		
		10/10/72		1.6	30	744		388	370	8	33	0.35	88	41	7	5.1	0.16	0.47	0.014	0.71	0.099	
		23/10/72	Neg			732		388	356	10	35	0.50	123	19	7	5.1	0.12	0.48	0.009	0.66		
		28/11/72	5			600		356	312	8	34	0.25	112	19	3	4.9	<0.01	1.0	0.004	0.49		
		6/3/73		15		178		88	78	5	9	0.30 0.75	27	5	2	3.3	0.45	0.66	0.024	2.1	0.23	
		4/4/73		0.8	15			320	305	7				~~.03~~			.08	.78	.12	.53	T. .05 SO_4 .04	Mn .03
		11/4/73		3.0	COD <30	290		144	136	4	15	.05	46	7	4	5.7	.22	.03	.032	.89	.11	
		27/4/73		0.8	15	580		320	305	7	32	.30	101	17	6	4.1	.08	.78	.12	.53	T. .050 SO_4 .040	Mn 0.03
		8/5/73		3.0	COD 35	560		294	252	9	40	0.25	94	14	7	7.1	.05	1.2	.030	.16	.102	
		22/8/73		1.2	16	640		348	307	7	39	0.20	110	18	7	6.7	.01	.66	.017	1.0	.096	Mn 0.08
		5/7/73		2.0	7	750		~~424~~	390	8	48	.50	128	25	6	3.1	.17	.13	.009	.45		
		26/7/73				720		392	362	8		.25	120	22	7	3.3	0.1	<.01	<.01			

Table / Summary of Water Analyses

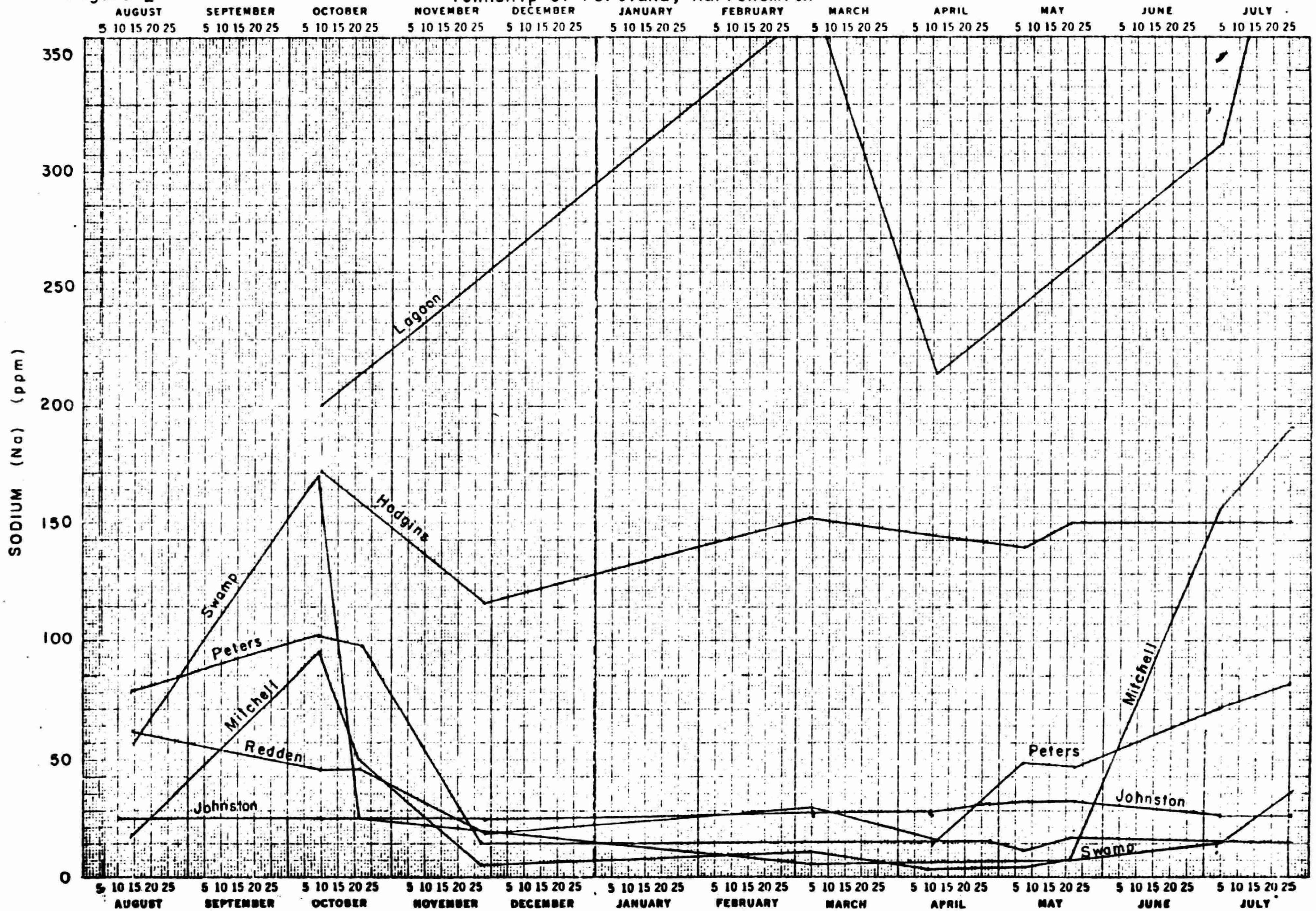
Prepared by GS

Source and Number	Location	Date Sampled	Lactic Acid (ppm)	BOD	TOC	Specific Conductance mmhos at 25°C	Total Dissolved Solids (ppm)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chemical Constituents in parts per million (ppm): Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Nitrogen: NH_4	NO_3	NO_2	Kjeld	Phosphorous (P)	Remarks
HIGHWAY SWAMP (CULVERT		4/8/72		3600	2162	3938				244		110						<0.01	0.001	36.0	4.6	
		16/8/72	Neg	1800	1450	3680			1760	243	<5	54	348	73	56	13	6.4	0.1	0.10	20		
		10/10/72		6000	2660*	4184		1670	308	380		54	496	105	170	175	80	<0.1	0.1	150	52	* TOTAL CARBON
		23/10/72	5			1106		552	520	63	6	9.3	182	23	23	13	0.6	1.4	0.53	4		
		6/3/73		10		258		128	116	8	8	1.3	39	~~7~~	4	3.2	0.39	0.5	0.024	2	0.18	
		11/4/73		3.0	COD 50	500		280	254	17	14		82	18	6	1.1	.01	.04	0.004	.83	0.065	
		8/5/73		3.0	COD <30	690		366	343	19	7	0.45	107	24 ~~2~~	7	1.7	<0.01	<.01	.003	.77	.08	
		22/5/73		16	19	620		348	320	15	5	0.70	102	22	6	1.1	<.01	.01	.002	.88	.078	Mn 0.18
		5/7/73		75	41	570		272	268	33	4	22.	64	27	~~14~~ ~~12~~ 12	3.1	4.0	.1	.04	7.9		
		24/7/73				600		284	269	93		3.6	77	22	35	8.8	7.4	<1.	<.1			

G -142
1 YEAR BY DAYS X 280 DIVNS.
CALENDER YEAR

Figure 2

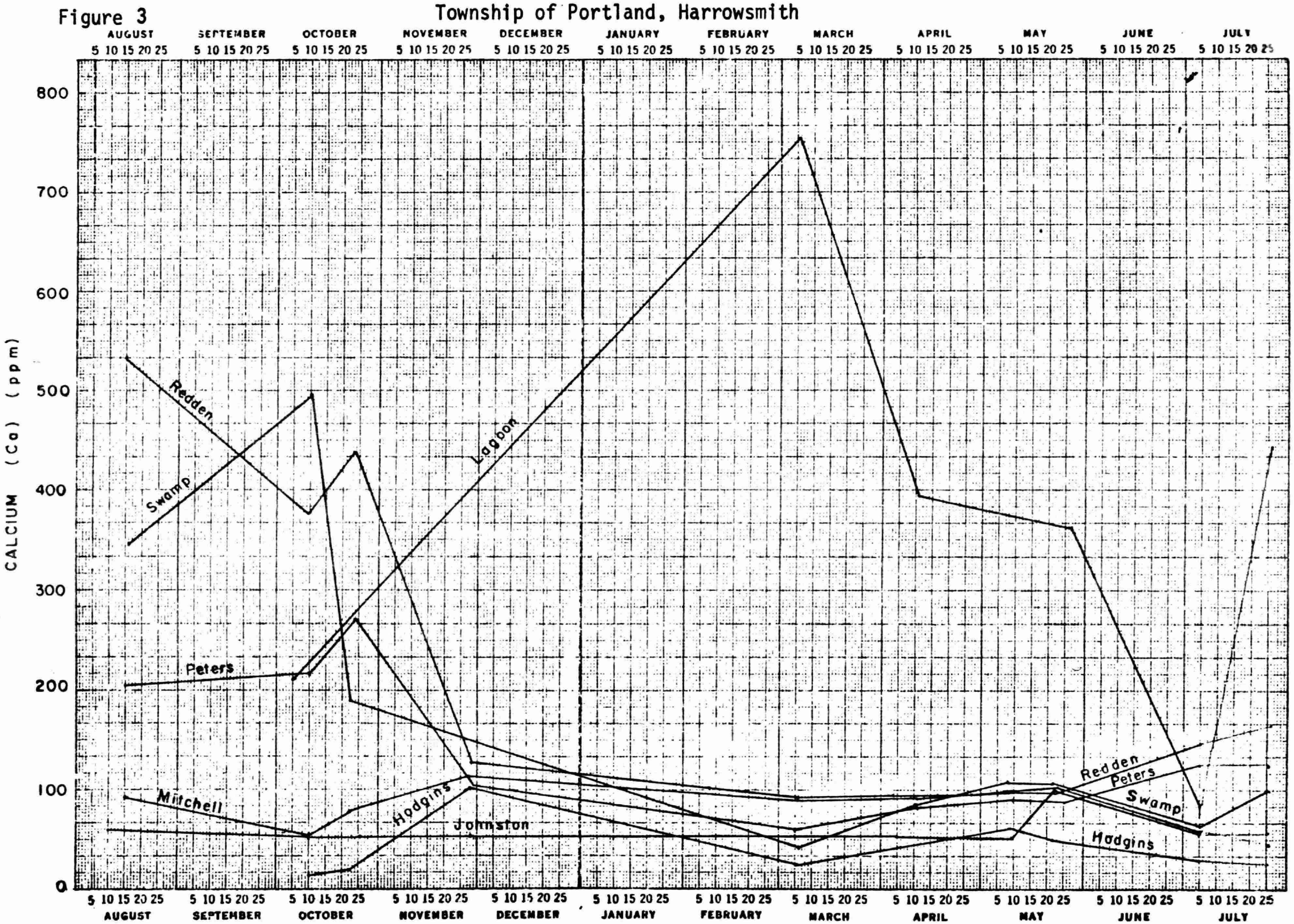
Township of Portland, Harrowsmith



G —142
1 YEAR BY DAYS X 280 DIVNS.
CALENDER YEAR

CC&S MICROGRAPH

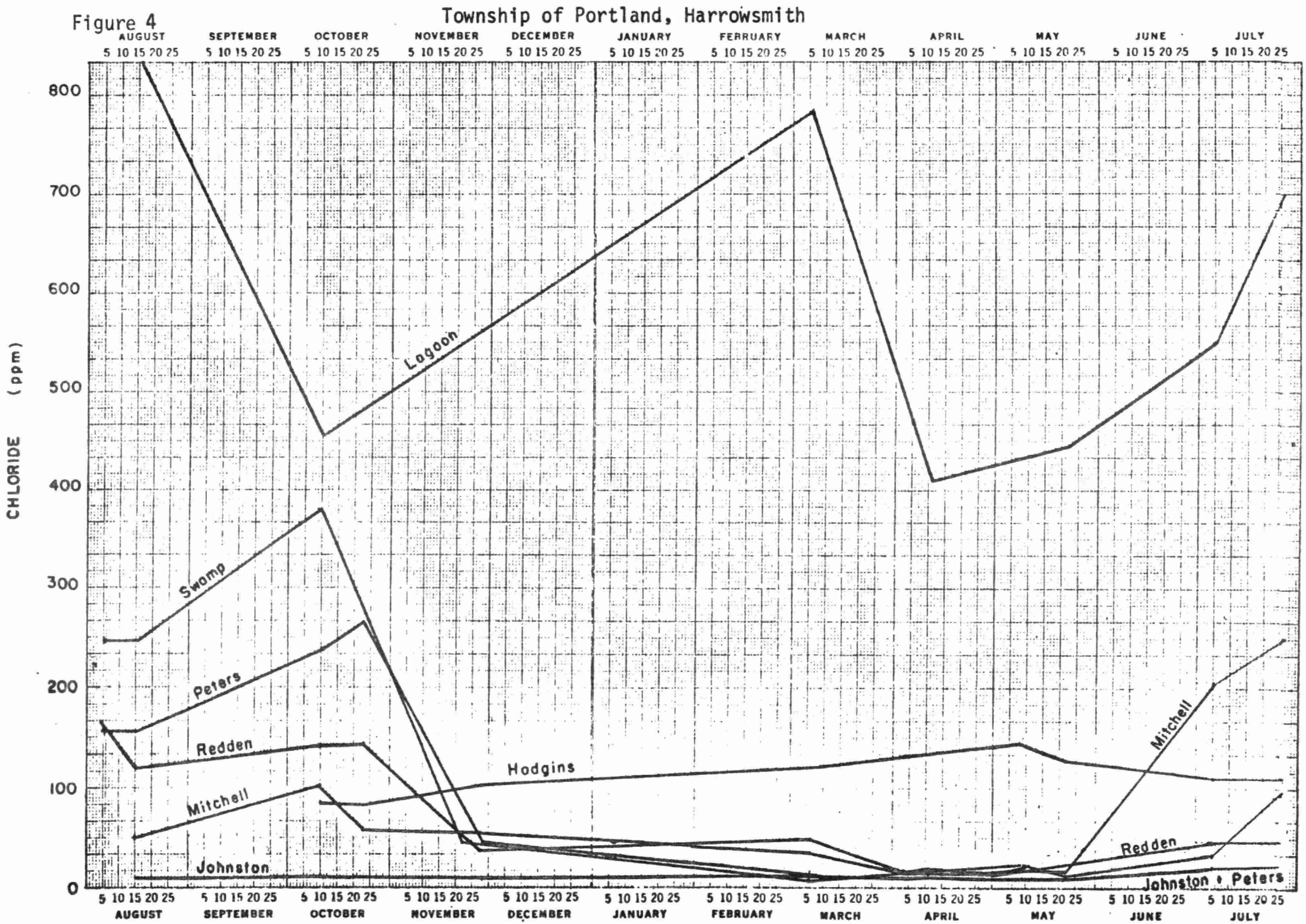
Figure 3



G -142
1 YEAR BY DAYS X 280 DIVNS.
CALENDER YEAR

CC&S MICROGRAPH

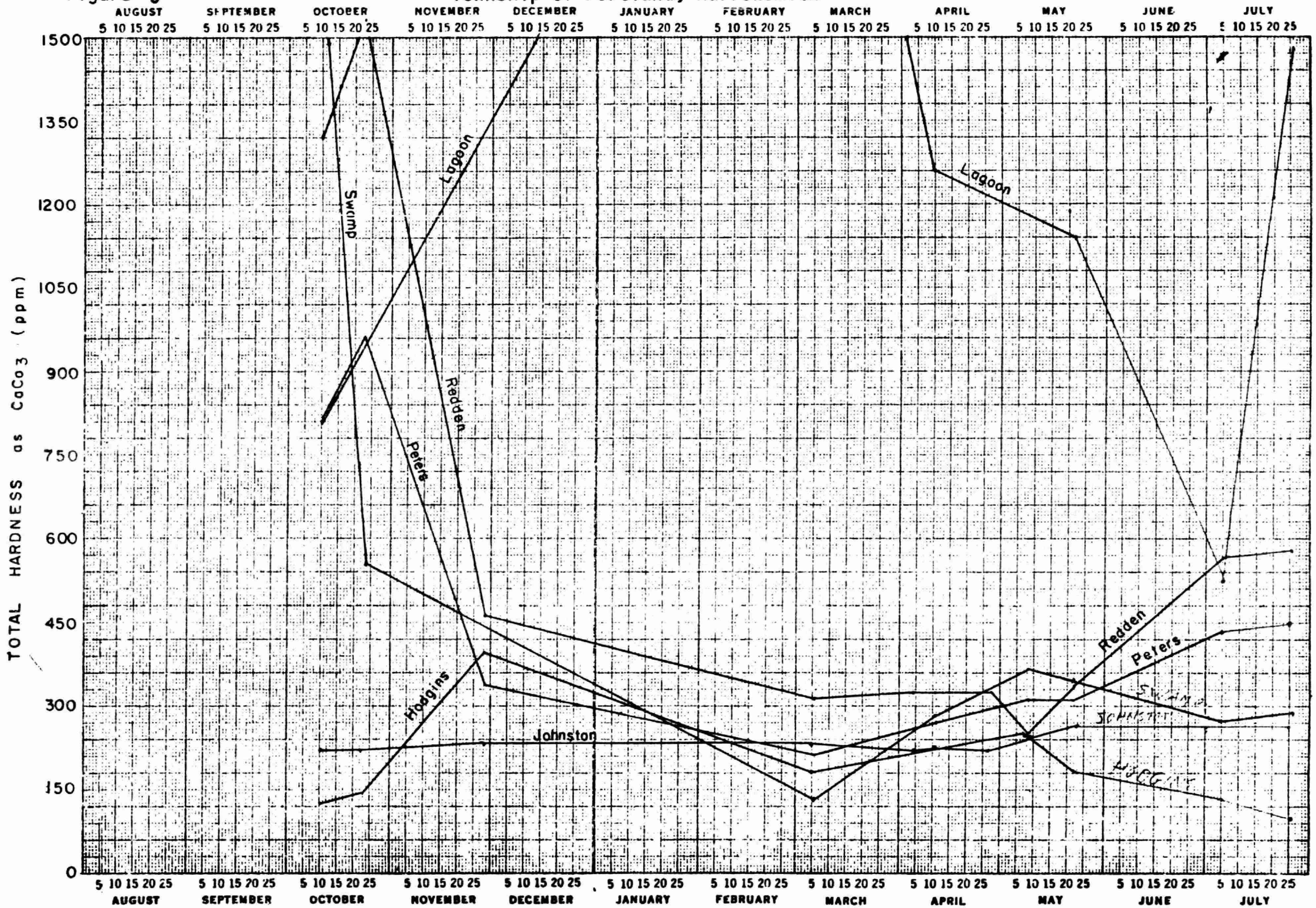
Figure 4



G ›-142
1 YEAR BY DAYS X 280 DIVNS.
CALENDER YEAR

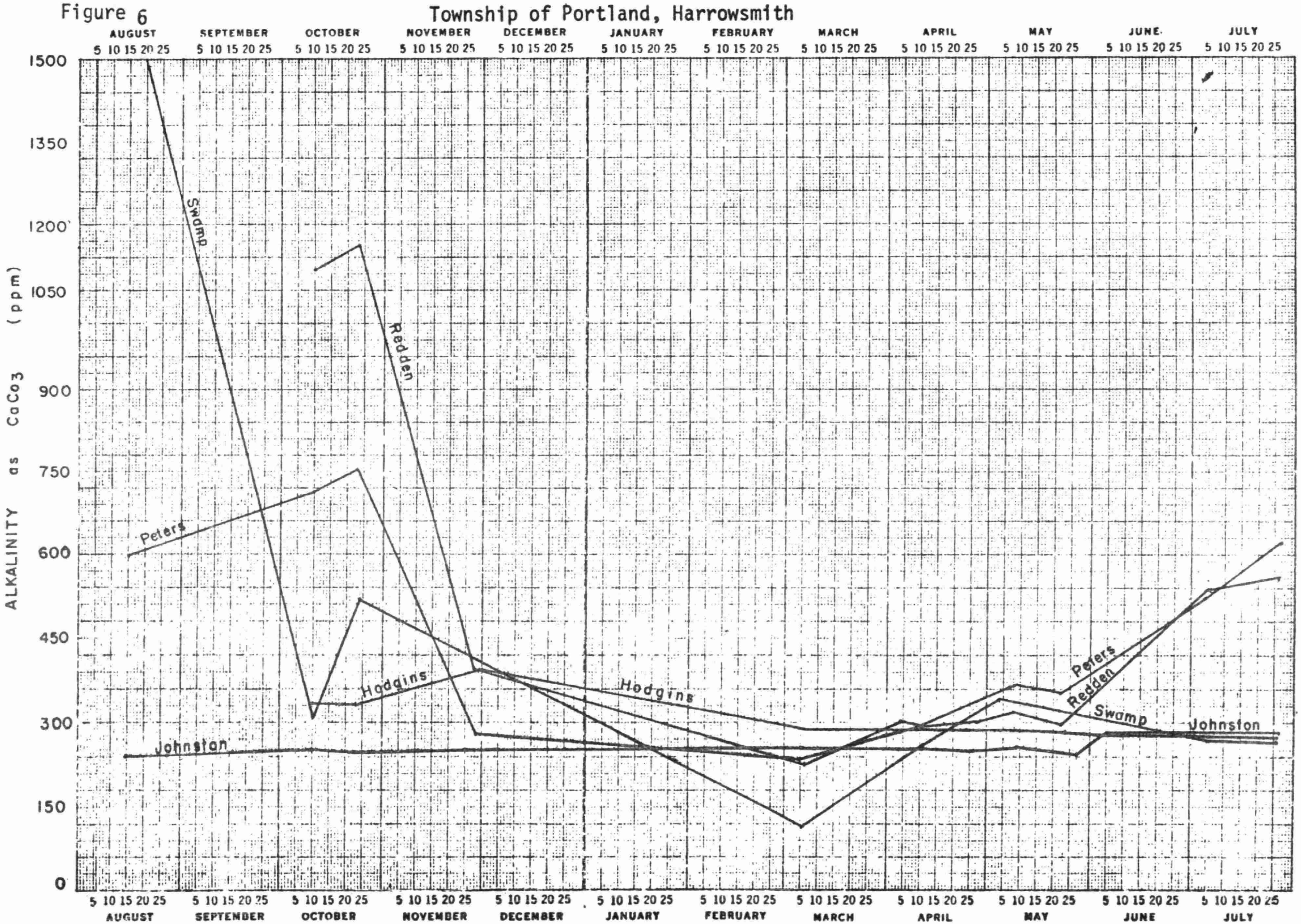
CCGS MICROGRAPH

Figure 5 Township of Portland, Harrowsmith



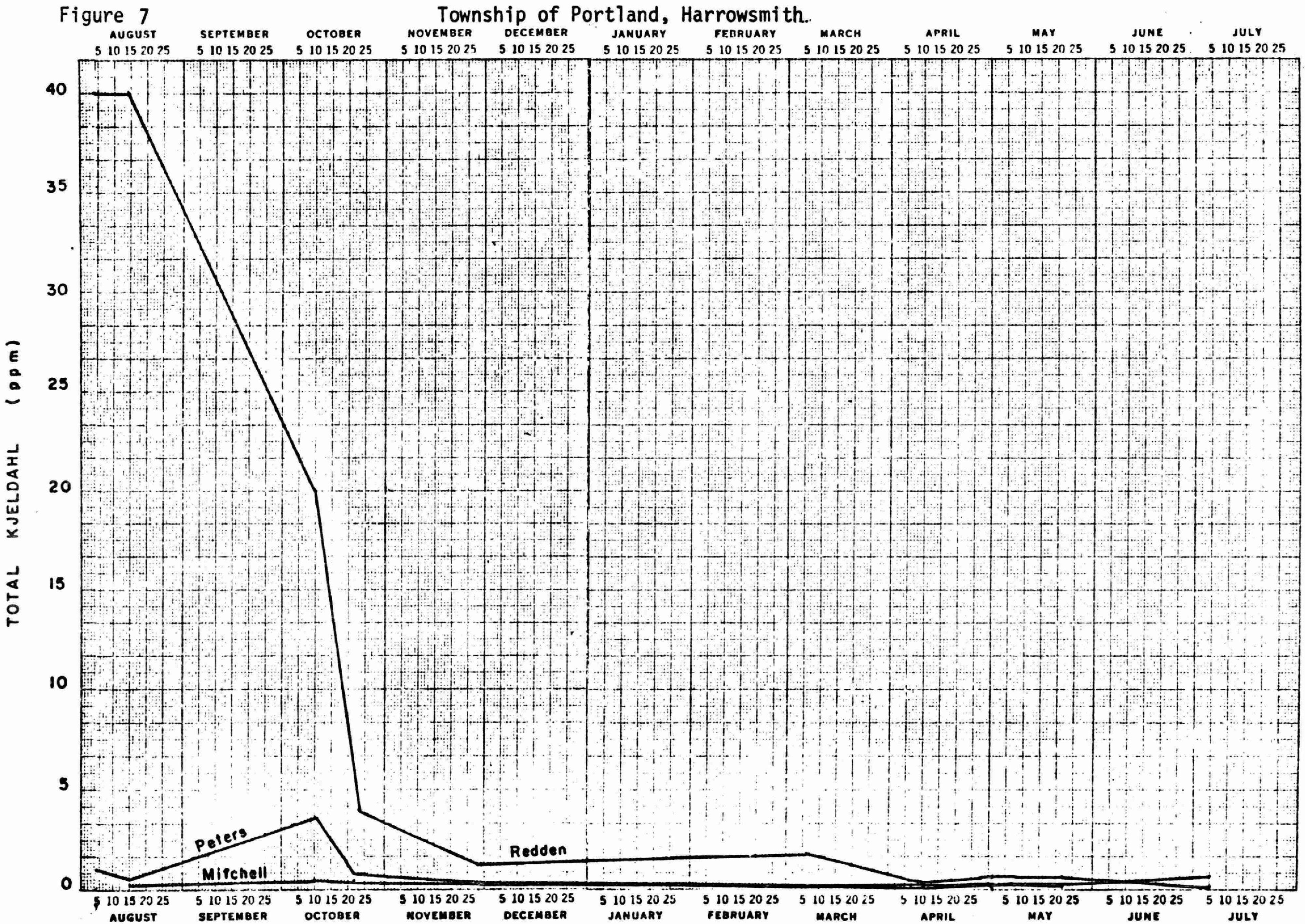
G -142
1 YEAR BY DAYS X 260 DIVNS.
CALENDER YEAR

Figure 6



G -142
1 YEAR BY DAYS X 280 DIVNS.
CALENDER YEAR

Figure 7



G -142
1 YEAR BY DAYS X 280 DIVNS.
CALENDER YEAR

Figure 8